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Machine Vision and Applications

Special Issue on Innovative applications of computer vision

Introduction

The computer vision field has the potential and promise to provide the technology to develop a wide variety of automated systems that are capable of operating under diverse conditions, delivering consistent results, and working in environments not suitable for humans. There are many real-world applications [1, 2] of computer vision including navigation, manufacturing, cartography, photo-interpretation, target recognition, medical image analysis, document analysis, remote sensing, space operations, etc. Generally, these applications are multidisciplinary in nature and require a combination of science, engineering, and art.

The successful development of computer vision applications is a very challenging task, especially in situations where (a) the environmental conditions are not in our control, (b) there is a lot of irrelevant information present in the image, and (c) there are no "perfect" image understanding algorithms. often, there are stringent requirements associated with performance, speed, cost, size, weight, and power. To demonstrate success requires a great deal of ingeniuity in all apsects of system engineering. Typically this includes developing sensor concepts, desgining and simulating algorithms, designing and implementing and integrating processing algorithms into a real-time hardware system. To validate the results and models in a real-world situation requires a testbed for carrying out scientific experimental designs using a large amount of appropriately chosen data and thorough evaluation of the performance results. This leads to much needed prediction of performance measures in a given situation and an understanding of strengths and weaknesses of various algorithms and systems.

The goals of this Special Issue are to provide the reader with some of the novel applications of Computer Vision that address and solve significant vision problems. The special issue is derived from the IEEE Workshop on Applications of Computer Vision that was held in Palm Springs, California, in November/December 1992, and the papers that we received in response to the call for papers for this Special Issue. The workshop was focussed on real-world applications of Computer Vision and its goal was to promote the interchange of ideas on developing practical and novel application-specific methods and analyzing their performance on real problems and large data sets.

Emphasis of this Special Issue is on novel research aspects and extensive experimental analysis for a given application domain. Purely applying standard techniques to a new application problem using a few test images is not sufficient. The application needs to identify a good match between the requirements of the application and the solution offered by the vision technique. The significance of the problem is measured by the usage of the technique, its efficiency and effectiveness, and ultimately the savings made.

In this issue

This Special Issue consists of five papers: the first two papers deal with autonomous navigation, the next two papers are concerned with manufacturing automation for defect detection and their diagnosis, and the last paper describes an image analysis system for color map processing.

The first paper by Shell and Dickmanns presents a visual navigation system that uses both visual and inertial sensor data for autonomous aircraft landing. The system uses an Extended Kalman Filter that involves the measurement of errors in the image domain to update a dynamic vehicle model and to predict environmental image features. Currently available and relatively inexpensive hardware is used to perform the image processing and visual search tasks on a sequence of images. The approach is demonstrated both in hardware-in-the-loop simulation and real test-flights.

The second paper by Xie et al. detects and tracks obstacles on a road by using a video camera and a point laser range finder. The obstacles are first detected in visual imagery and then the laser is used to confirm or reject the presence of the obstacle and to measure its range from the vehicle. The confirmed obstacles are tracked with the laser range finder. Line segments are used to represent the obstacles. The paper has implemented the complete system in hardware/software and shows experimental results.

The third paper by Khalaj et al. presents a signal processing approach for defect detection in images with repetitive patterns that are found in wafers and masks used for integrated circuit fabrication. The approach uses efficient high-resolution spectral estimation techniques to estimate periods with subpixel accuracy in both horizontal and vertical directions. This information is then used to extract the building block of the repeated patterns which is a defect free reference image for making comparisons with the actual image. The defects are determined by subtracting shifted versions of the reference image from the actual image.

In the fourth paper, Perner presents a knowledge-based image inspection system for offset printing to detect, classify and identify the causes of misprint defects, so that the printing process can be continuously monitored and controlled. There are 47 classes of defects related with the production of color, tonal value, sharpness, evenness and correct appearance of image parts. An expert system keeps the knowledge of defects and the knowledge (aquired by interaction with an expert) that causes the defects. The image analysis and feature extraction algorithms are guided by the kind of defects that one expects to see in the image. The system provides information to the operator about what action has to be taken in order to eliminate the causes of the defect. These results can be used for automated process control to improve or maintain the quality of the manufactured products.

The last paper by Ebi et al. presents an image analysis system for automatic data acquisition from colored topographic maps. These maps are on a medium scale (1:10,000 to 1:50,000) and have a relatively high density of objects. The authors describe various processing steps used in data acquisition, image segmentation to extract structural primitives, their properties and relations, and knowledge-based image understanding. The hierarchical, symbolic description of the map so obtained can be integrated into a geographic information system.

In summary

I hope that the readers will find the Special Issue valuable and worthwile. A Special issue can cover only a small number of applications. There is some awareness in the vision community that "...much of our current models and methodologies do not seem to scale out of limited 'toy' domains" [3]. Applications are testing grounds where "sophisticated" algorithms, new architectures, and technology meet the reality. In recent years we have seen more understanding and emphasis on applications. I believe that the trend will continue as more people not only develop sound theories to solve specific vision problems but also derive the pleasure and satisfaction of trying out their "best" algorithms on real-world problems.

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